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(71) Applicant : **KABUSHIKI KAISHA TOSHIBA**
72, Horikawa-cho
Saiwai-ku
Kawasaki-shi Kanagawa-ken 210 (JP)

(71) Applicant : **TOSHIBA AVE CO., LTD**
3-3-9, Shinbashi
Minato-ku, Tokyo (JP)

(72) Inventor : **Murayama, Akihiro, c/o**
Intell.Property Div.
K.K. Toshiba,
1-1, Shibaura 1-chome,
Minato-ku
Tokyo (JP)
Inventor : **Horiguchi, Yoshinori, c/o**
Intell.Property Div.
K.K. Toshiba,
1-1, Shibaura 1-chome,
Minato-ku
Tokyo (JP)
Inventor : **Morita, Makoto, c/o Intell.Property Div.**
K.K. Toshiba,
1-1, Shibaura 1-chome,
Minato-ku
Tokyo (JP)

(74) Representative : **Maury, Richard Philip**
MARKS & CLERK,
57-60 Lincoln's Inn Fields
London WC2A 3LS (GB)

(54) Secam chroma processing circuit and automatic frequency adjusting circuit.

(57) Changing ω_0 in a transfer function is much easier than recombining transfer functions of a built-in filter. Noticing this point, the circuit uses a method of shifting the frequency characteristic of a bell filer or antibell filter instead of changing a bell and antibell and uses means for changing central frequencies while keeping the amplitude characteristic constant. Therefore, input sides of filters can be changed so that a signal processing system can also shift frequencies. Moreover, by separately preparing a reference signal, adjustment is omitted by making the reference signal pass through the bell and antibell filters at the same time and monitoring and adjusting filter characteristics one by one.

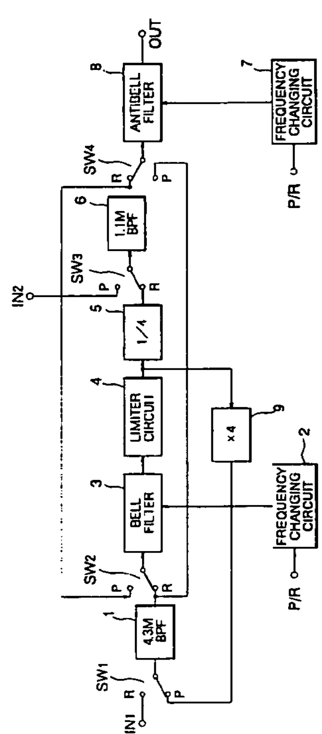

FIG. 1

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The present invention relates an SECAM chroma processing circuit for automatically adjusting SECAM-type chroma signal processing and preferably used mainly for a video tape recorder (VTR).

In the SECAM system, an R-Y signal (red color-difference signal) frequency-modulated at the carrier frequency of 4.40625 MHz and a B-Y signal (blue color-difference signal) frequency-modulated at the carrier frequency of 4.25 MHz are alternately transmitted every horizontal period. The amplitude of these frequency-modulated signals is suppressed in the vicinity of carrier frequencies of the signals at the transmission side in order to decrease dot disturbances by suppressing a carrier wave amplitude nearby the achromatic wavelength. This suppression filter is called an antibell filter because its characteristic has an antibell shape. The central frequency of the antibell filter during transmission is 4.286 MHz. The frequency of 4.286 MHz is hereafter shown as 4.3 MHz. For a television picture tube, a signal is processed after passing it through a filter in which the signal amplitude increases in the vicinity of a carrier frequency to offset the group delay characteristic and amplitude characteristic at the transmission side, inversely to the antifilter of the transmission side.

In the chroma recording/reproducing system of a VTR, the SECAM system includes L-SECAM system and ME-SECAM system. Of these two systems, the L-SECAM system uses a method of dividing the chroma signal component of a color television signal into four parts to convert the frequency into a low frequency and record the frequency and multiplying the frequency for reproduction up to four times to convert the frequency into the original high sub-carrier-wave frequency.

FIG. 16 shows the processing system of an existing VTR recording/reproducing system of the L-SECAM system.

For recording, switches SW_9 and SW_{10} are connected to the R side. A color television signal inputted to an REC chroma input terminal IN is supplied to 4.3 MHz BPF 81 through the switch SW_9. The BPF 81 extracts only an SECAM chroma signal from the color television signal. The chroma signal is inputted to a 4.3 MHz bell/antibell filter 82. The 4.3 MHz bell/antibell filter 82 serves as a bell filter for recording. A limiter circuit 83 amplifies the output of the 4.3 MHz bell/antibell filter 82. A four-part-divider 84 decreases the frequency of the output signal of the limiter circuit 83 to 1/4. The SECAM chroma signal whose frequency is thus decreased to 1.1 MHz is inputted to the antibell filter 85 having the central frequency of 1.0715 MHz (1.0715 MHz is hereafter shown as 1.1 MHz). The output of the antibell filter 85 is supplied to 1.4 MHz LPF 86 through the switch SW_{10}. The 1.4 MHz LPF 86 suppresses unnecessary components at a high frequency band and extracts only a necessary band component to output it to an REC chroma output terminal OUT.

Because the SECAM chroma component of the received television signal is the frequency-modulated signal whose amplitude characteristic is suppressed as described above, the chroma signal amplitude varies depending on the hue. The 4.3 MHz bell filter 82 is a filter for returning the amplitude characteristic and the group delay characteristic operated at the transmission side to their original state. The amplitude of the frequency-modulated signal passing through the 4.3 MHz bell filter 82 becomes constant independently of the hue. The amplitude characteristic is flat even after dividing this signal into four parts and converting it into a low frequency. When passing the output of the 4.3 MHz bell filter 82 through the 1.1 MHz antibell filter 85, a suppression effect is obtained like the transmission side and also, an effect for decreasing the energy of the frequency-modulated signal and decreasing disturbances against the frequency-modulated signal of Y is obtained. Therefore, the envelope of the output signal of the REC chroma terminal OUT becomes apparently the same as that of the 4.3 MHz chroma signal.

For reproduction, the switches SW_9 and SW_{10} are connected to the P side. The SECAM chroma signal recorded by the above method is inputted through a PB chroma input PI terminal. The SECAM chroma signal inputted through the PB chroma input PI terminal is inputted to 1.4 MHz LPF 86 through a 1.1 MHz bell filter 87 and the switch SW_{10}. Though the FM component of a Y signal is also superimposed on a VTR reproduction signal, only the low-frequency chroma component is left after the FM component passes through the 1.4 MHz LPF 86. A limiter circuit 88 amplifies the output of the 1.4 MHz LPF 86. A four-time-multiplier 89 returns the output of the limiter circuit 88 to a four-time frequency. The output signal of the four-time-multiplier 89 is inputted to the 4.3 MHz BPF 81 through the switch SW_9. The output of the 4.3 MHz BPF 81 is inputted to the 4.3 MHz bell/antibell filter 82. The 4.3 MHz bell/antibell filter 82 serves as an antibell filter for reproduction. The output of the 4.3 MHz bell/antibell filter 82 is outputted from a PB chroma output terminal PO.

The signal inputted to the PB chroma input terminal PI receives carrier wave suppression due to the antibell filter because the signal is a recorded chroma signal. Therefore, the amplitude of the signal varies depending on the hue. The 1.1 MHz bell filter 87 cancels the characteristic to make the amplitude characteristic flat. The SECAM chroma signal which is made flat is amplified up to four times and converted into a high frequency to return the frequency of the signal to the transmitted frequency band. Moreover, to reproduce the amplitude characteristic for transmission, the signal is outputted through the 4.3 MHz bell/antibell filter 82.

The 4.3 MHz bell/antibell filter 82 shown in FIG.

16 uses one resonator both for recording and reproduction and changes its characteristics for recording and reproduction. The above change uses the method disclosed in Japanese Patent Publication No. Hei 4-24918 (filter circuit) (1992). In this case, however, the denominator and numerator of the transfer function of the bell filter are replaced each other by contriving circuits so that the antibell characteristic is obtained.

In this case, however, because the bell and antibell filters are realized with resonators, adjustment is required and moreover, there is a problem that many parts are necessary because all filters including BPF and LPF comprise discrete elements. Moreover, to incorporate every filter into an IC and incorporate discrete elements into the IC, the bells and antibell must be changed. Therefore, a fatal problem occurs that a signal processing system must be constituted with built-in filters. Moreover, because the built-in filter is not suitable for the operation of replacing the denominator and numerator of its transfer function each other, it is basically difficult to realize the impedance replacement shown in Japanese Patent Publication No. Hei 4-24918 (1992). Furthermore, the bell and antibell filters require an adjustment accuracy of approx. 0.5% for their central frequency. Therefore, to incorporate the filters into the IC, a measure for omitting adjustment must be added separately. Unless there are a signal processing system meeting the above requirements and an automatic adjusting method preferred to the system, it is impossible to incorporate all filter elements which are hitherto discrete elements into an IC.

The bell and antibell filters are indispensable not only for recording or reproduction by a VTR but also for transmission or reception of television signals of the SECAM system.

When the transfer functions of the bell and antibell filter are assumed as B(s) and AB(s) respectively, B(s) and AB(s) are shown by the following expressions (1) and (2).

$$B(s) = \frac{S^2 + \frac{\omega_0}{Q_n}.S + \omega^2}{S^2 + \frac{\omega_0}{Q_p}.S + \omega^2} \quad (1)$$

$$AB(s) = \frac{S^2 + \frac{\omega_0}{Q_p}.S + \omega^2}{S^2 + \frac{\omega_0}{Q_n}.S + \omega^2} \quad (2)$$

Q_n and Q_p in the expressions (1) and (2) represent an independent Q respectively and their values are $(1.6)^{1/2}$ and 16 respectively. FIGs. 17 and 18 show the frequency-gain characteristic of a bell filter and the frequency-phase characteristic of it respectively. FIGs. 19 and 20 show the frequency-gain characteristic of an antibell filter and the frequency-phase characteristic of it respectively.

The phase characteristic of the antibell filter does not belong to the phase characteristic of a general filter but the antibell filter has a characteristic that the phase is 0° at the central frequency.

The circuit constitution of an existing antibell filter is described below. FIG. 21 shows a circuit in which an antibell filter comprises discrete elements. In FIG. 21, symbol in represents an input terminal, out represents an output terminal, R_1 to R_3 represent resistances, L represents a coil, and C represents a capacitor. When assuming the transfer function of this circuit as ABd(s), the following expression (3) is obtained.

$$ABd(s) = \frac{R_2 + R_3}{R_1 + R_2 + R_3} \cdot \frac{S^2 + \frac{R_2.R_3}{L(R_2 + R_3)}.S + \frac{1}{LC}}{S^2 + \frac{R_3(R_1 + R_2)}{L(R_1 + R_2 + R_3)}.S + \frac{1}{LC}} \quad (3)$$

Results of obtaining Q_n and Q_p by the above expression (3) are shown by the following expressions (4) and (5).

$$Q_n = \frac{L(R_1 + R_2 + R_3)}{R_3(R_1 + R_2)} \quad (4)$$

$$Q_p = \frac{L(R_2 + R_3)}{R_2.R_3} \quad (5)$$

The central frequency (hereafter shown as f_0) of the filter is shown by the following expression (6).

$$f_0 = \frac{1}{(2\pi\sqrt{LC})} \text{ Hz} \quad (6)$$

That is, a gain is determined by a resistance value, Q is determined by inductance and resistance values, and f_0 is determined by inductance and capacitance values.

In general, the central frequency f_0 of this circuit is adjusted by using a variable inductance for L in FIG. 21. In this case, the f_0 adjusting accuracy is considered below when the manufacturing fluctuation of the variable inductance is assumed as ±15% and that of other elements is assumed as 0. When assuming that the central frequency f_c of the variable inductance at the central value is shown by the following expression (7) and the central frequency f_c' at the maximum or minimum inductance is shown by the following expression (8), the variable range of the central frequencies is obtained as ±7% from the following expression (9).

$$f_c = \frac{1}{2\pi\sqrt{LC}} \quad (7)$$

$$f_c' = \frac{1}{2\pi\sqrt{1.15LC}} \quad (8)$$

$$\frac{f_c'}{f_c} = \pm\sqrt{1.15} = \pm 1.07 \quad (9)$$

When the central frequency of the antibell filter is assumed as 4.286 MHz, the variable range comes to ±300 KHz. If the inductance varying method uses

a rotary system which is the six-turn type, the frequency changes by 5 KHz only for 1/60 turn. Thereby, it is found that an antibell filter must be adjusted very strictly.

FIG. 22 shows a general automatic filter-frequency adjusting system. Symbol 2210 represents an input terminal, 2211 represents an output terminal, 2212 represents a filter to be adjusted, and 2213 represents a phase detector. In this case, it is necessary to use a filter to be adjusted whose cutoff frequency can be varied by voltage or current and a phase detector which outputs a voltage or current corresponding to a deviation from the phase difference of 90°.

When it is assumed that the filter to be adjusted uses a secondary LPF and the cutoff frequency is 1 MHz, the phase characteristic is as shown in FIG. 23.

To perform automatic adjustment, it is necessary to input a frequency equal to the cutoff frequency to the input terminal of the filter. If the cutoff frequency of the filter to be adjusted is deviated for any reason, the phase detector outputs a voltage or current corresponding to the deviation to the filter to be adjusted. By this feedback, the filter to be adjusted is automatically adjusted.

However, it is very difficult to automatically adjust bell and antibell filters because there is not a point where the phase rotates by 90° in view of the circuit constitution.

As described above, the existing system requires a lot of parts and adjustment of them because all filters including BPF and LPF comprise discrete elements. To completely incorporate filters and discrete elements into an IC, it is necessary to change bell and antibell. Moreover, it is difficult to realize the replacement of impedances of the built-in filters for adjustment of them. Bell and antibell filters require an adjustment accuracy of approx. 0.5% for their central frequencies. Moreover, to incorporate the filters into the IC, a measure for omitting adjustment is necessary. Therefore, unless there is any proper automatic adjustment method, it is impossible to all the filters which are discrete elements in the IC.

Bell and antibell filters constituted with discrete elements have problems that the f_0 adjustment requires many hands and a lot of time and moreover they are weak in mechanical vibrations and deterioration with age. Moreover, because there is not a point where the phase rotates up to 90°, it is difficult to make automatic adjustment.

It is an object of the present invention to provide a low-cost and rational SECAM chroma processing circuit by proposing a SECAM chroma signal processing system to be properly constituted with built-in filters and adding a method for omitting the adjustment of the built-in filters.

Moreover, the present invention provides an automatic frequency adjusting circuit for automatically adjusting the central frequencies of bell and antibell filters built in an IC very accurately.

Changing ω_0 of a transfer function is much easier than recombining transfer functions of a built-in filter. Noticing this point, the circuit of the present invention uses a method of shifting the frequency characteristic of a bell filter or antibell filter instead of changing bell and antibell and means for changing central frequencies while keeping the amplitude characteristic constant. Therefore, input sides of filters are changed instead of changing output signals of the bell and antibell filters so that the signal processing system can shift frequencies. Moreover, the above object is achieved by separately preparing a reference signal, sending the reference signal to the bell and antibell filters at the same time to successively monitor and adjust the filter characteristic and thereby realizing a measure for omitting adjustment.

By using the frequency shifting method, it is possible to change characteristics suitable for a built-in filter and incorporate a filter which is hitherto set outside into an IC. Moreover, because connections of BPF and bell filter can be changed, it is possible to realize the recording/reproduction function same as the existing one even if bell and antibell filters are constituted with built-in filters for shifting frequencies. Furthermore, because operations from input to output can be realized by the same processing system, it is possible to process signals in one direction and share a chroma input pin.

Because the reference signal is directly inputted to a built-in filter to monitor the frequency characteristic, it is possible to eliminate all deviation factors such as fluctuation of time constants in an IC, temperature drift of characteristics, and change with time.

Moreover, the present invention makes it possible to obtain the output of the secondary LPF in a circuit having a constitution in which the transfer functions of bell and antibell filters is transformed into the mathematical expression of [1-(transfer function of BPF)]. The secondary LPF is characterized by obtaining the phase characteristic that the phase rotates by 90° at the central frequency and detecting the phase of the output of the secondary LPF to apply feedback to bell and antibell filters. Thereby, because the central frequencies of bell and antibell filters can automatically be adjusted, it is possible to incorporate bell and antibell filters into an IC.

FIG. 1 is a circuit block diagram for explaining an embodiment of the present invention;

FIG. 2 is a characteristic diagram for explaining the operation of the circuit in FIG. 1;

FIG. 3 is a characteristic diagram for explaining the operation of the circuit in FIG. 1;

FIG. 4 is a circuit block diagram for explaining the input section of the bell and antibell filters in FIG. 1;

FIG. 5 is a circuit block diagram for explaining the

automatic adjustment in FIG. 1;

FIG. 6 is a circuit block diagram for explaining FIG. 5;

FIG. 7 is a circuit block diagram for explaining another embodiment of the present invention;

FIG. 8 is an illustration for explaining the concept of the present invention;

FIG. 9 is a circuit block diagram showing the main portion in FIG. 8;

FIG. 10 is a circuit block diagram for explaining an embodiment of the present invention for automatically adjusting the frequency of an antibell filter;

FIG. 11 is a phase characteristic diagram of the antibell filter of the present invention;

FIG. 12 is a circuit diagram for specifically explaining the phase detector in FIG. 10;

FIG. 13 is a waveform diagram for explaining the relation between input and output voltages of the phase detector in FIG. 10;

FIG. 14 is a circuit block diagram for explaining still another embodiment of the present invention for automatically adjusting the frequency of an antibell filter;

FIG. 15 a waveform diagram for explaining the relation between input and output voltages of the phase detector in FIG. 14;

FIG. 16 is a circuit block diagram for explaining an existing SECAM chroma processing circuit;

FIG. 17 is a characteristic diagram showing the relation between frequency and gain of a bell filter;

FIG. 18 is a characteristic diagram showing the relation between frequency and phase of a bell filter;

FIG. 19 is a characteristic diagram showing the relation between frequency and gain of an antibell filter;

FIG. 20 is a characteristic diagram showing the relation between frequency and phase of an antibell filter;

FIG. 21 is a circuit diagram of an existing antibell filter;

FIG. 22 is a diagram of an existing system for automatically adjusting the frequency of a filter; and

FIG. 23 is a characteristic diagram showing the relation between frequency and phase of a secondary LPF.

Embodiments of the present invention are described below in detail by referring to the accompanying drawings.

FIG. 1 shows an embodiment of the present invention. First, for recording, a SECAM color television signal inputted from an REC chroma input terminal IN_1 is inputted to a 4.3 MHz BPF (Band Pass Filter) 1 through a switch SW_1 connected to the R side. The output of the BPF 1 is inputted to a bell filter 3 through a switch SW_2 connected to the R side. For recording, the frequency of the bell filter 3 is changed to 4.3 MHz by a frequency changing circuit 2. The output of the bell filter 3 is amplified by a limiter circuit 4. A signal amplified by the limiter circuit 4 is divided by a four-part-divider 5. The signal divided by the four-part-divider 5 is inputted to a 1.1 MHz BPF 6 through a switch SW_3 connected to the R side. The output of the BPF 6 is inputted to an antibell filter 8 through a switch SW_4 connected to the R side. For recording, the frequency of the antibell filter 8 is changed to 1.1 MHz by a frequency changing circuit 7. The output of the antibell filter 8 is outputted to a chroma output terminal OUT.

For recording, the 4.3 MHz BPF 1 extracts only the SECAM chroma signal component from the SECAM color television signal supplied to the REC chroma input terminal IN_1. At this point of time, the chroma signal amplitude differs depending on the hue because of the effect of the antibell filter 8 at the transmission side. Because the bell filter 3 cancels the effect of the antibell filter 8 at the transmission side, an SECAM chroma FM signal with a constant amplitude can be obtained by the bell filter 3 regardless of the hue. The limiter 4 and four-part-divider 5 convert the SECAM chroma FM signal with a constant amplitude into a low frequency (1.1 MHz). The 1.1 MHz BPF 6 removes distortional component produced in low-frequency conversion and suppresses unnecessary band component. Finally, the antibell filter 8 suppresses FM-wave energy nearby the carrier wave frequency similarly to the case of the transmission side. The envelope waveform of the output of the antibell filter 8 becomes apparently same as that of the signal outputted from the REC chroma input terminal IN_1. It is possible to decrease the disturbance effect against the FM component of a luminance signal to be synthesized later by the above suppression effect.

For reproduction, an SECAM-type VTR reproduction signal inputted from a PB chroma input terminal IN_2 is inputted to the 1.1 MHz BPF 6 through the switch SW_3 connected to the P side. The output of the BPF 6 is inputted to the bell filter 3 through the switch SW_2 connected to the P side. For reproduction, the frequency of the bell filter 3 is changed to 1.1 MHz by the frequency changing circuit 2. The output of the bell filter 3 is amplified by the limiter circuit 4. The output of the limiter circuit 4 is inputted to a four-time-multiplier 9. A signal multiplied up to four times by the four-time-multiplier 9 is inputted to the 4.3 MHz BPF 1 through the switch SW_1 connected to the P side. The output of the BPF 1 is inputted to the antibell filter 8 through the switch SW_4 connected to the P side. For reproduction, the frequency of the antibell filter 8 is changed to 4.3 MHz by the frequency changing circuit 7. The output of the antibell filter 8 is outputted to a chroma output terminal OUT.

For reproduction, the 1.1 MHz BPF 6 extracts the chroma signal converted into a low frequency (1.1 MHz) from the SECAM-type VTR reproduction signal

supplied to the PB chroma input terminal IN_2. The bell filter 3 offsets the effect of the antibell filter 8 applied for recording. The amplitude of the input signal of the bell filter 3 differs depending on the hue. However, because the effect is canceled for the output of the bell filter 3, the amplitude becomes constant. Strictly saying, Q of an antibell for recording may be set to a slightly small value deviated from the ideal characteristic and the amplitude of the output of the bell filter 3 may not completely become constant. However, the following description is made by assuming that the antibell has the ideal characteristic. The four-time-multiplier 9 converts the output of the limiter 4 into a signal with a high frequency (4.3 MHz). The output of the four-time-multiplier 9 contains distortion and unnecessary band component similarly to the case of recording. The 4.3 MHz BPF 1 suppresses and removes the distortion and unnecessary band component. The antibell filter 8 finally suppresses the amplitude of the output of the BPF 1 again and transforms the output into a signal with the same waveform as a transmitted SECAM chroma signal to output it.

The bell filter 3 and the antibell filter 8, as described above, shift the frequencies of these circuits by the frequency changing circuits 2 and 7 for recording and reproduction. As functions, frequencies of the bell filter 3 are changed and automatically adjusted. The function and circuit of this portion are described in detail later.

The bell and antibell filters 3 and 8 can be constituted with analog filter circuits. Concrete examples of the filters are disclosed in Japanese Patent Application Laid-Open Nos. Hei 3-85808 (1991) and Hei 3-195208 (1991). For the filters 3 and 8, Q and ω_0 of a transfer function can be determined by gm and capacity. Q can be set by the ratio (product of the gm ratio between gm groups and the ratio between capacity groups) between capacity and gm (voltage-current conversion rate of a differential amplifier or the like) and ω_0 has the dimension of gm/capacity. Because gm depends on current as already known, a method for controlling gm by current is generally used for these filters. Operations of the frequency changing circuits 2 and 7 are further described below by referring to FIGs. 2 and 3. In the case of the bell filter 3, the characteristic for recording is shown by R in FIG. 2 and the central frequency comes to approx. 4.3 MHz. The frequency changing circuit 2 supplies the current providing this characteristic to the bell filter 3.

The characteristic for reproduction, as shown by P in FIG. 2, shows the shape in which Q for recording is left as it is and only the central frequency is decreased to 1.1 MHz. Because the frequency of 1.1 MHz is obtained by dividing 4.3 MHz into four parts, that is, decreasing to 4:1, the frequency changing circuit 2 divides the control current information supplied for recording into 4:1 to output it. Because Q is a product of capacity and gm and has the dimension of a constant, it does not change even if the absolute value of gm changes while the gm ratio is kept constant. Therefore, the state of P in FIG. 2 can be realized by changing gm while keeping Q constant. Change of gm can very easily be achieved by controlling only the current applied to a gm amplifier for determining ω_0 in the gm amplifier group constituting a built-in filter by the frequency changing circuit 2.

The same technique can also be applied to the case of the antibell filter 8. The filter 8 under the state of P in FIG. 3 for reproduction is used under the state of R for recording. Also in this case, change can easily be achieved only by applying the control current divided into 4:1 or amplified. Therefore, the state of P in FIG. 3 can be realized by changing ω_0 while keeping Q constant. Because the transfer functions of bell and antibell are already known, the description of them is omitted. In the case of the antibell, the denominator and numerator of the transfer function are replaced each other.

In the above description, the built-in filter is controlled by current. However, when an OTA (Operational-Transconductance-Amplifier) known as a MOS-FET-C filter is used, the filter is controlled by voltage. In this case, because the frequency changing circuit outputs voltage, it is only necessary to change control voltages so that the frequency comes to 4:1 when changing frequencies. Frequency shift can be realized by a simple circuit both for current and voltage.

In the case of a built-in filter, however, it may not be possible to optionally set an input dynamic range. A signal inputted to the REC chroma input IN_1 or PB chroma input IN_2 relates to a tuner or electromagnetic conversion for recording or reproduction and the input level fluctuates. Because the output of the 4.3 MHz BPF 1 directly receives the fluctuation, the level to be inputted to the bell filter 3 also fluctuates. When the input dynamic range of the built-in filter is smaller than the fluctuation, the filter characteristic may be deviated from a set characteristic. Therefore attention should be paid to it. In this case, it is necessary to set an ACC (Automatic Chroma Control) circuit before the bell filter 3 and the antibell filter 8 so that the chroma signal amplitude to be inputted to the bell filter 3 and antibell filter 8 does not exceed the input dynamic range.

FIG. 4 shows an example in which an ACC loop comprising an ACC amplifier 41 and an ACC detector 42 is constituted between the fixed contact of the switch SW_2 at the bell filter 3 side and the bell filter 3. The gain of the ACC amplifier 41 can be controlled by the ACC detector 42 and the ACC detector 42 monitors the input amplitude of the bell filter 3. When the input amplitude of the bell filter 3 reaches a set value or more, the ACC detector 42 outputs control information to the ACC amplifier 41 so as to decrease the gain.

Thus, it is possible to stabilize the chroma signal

amplitude inputted to the bell filter 3 in a certain range and remove fluctuation from chroma signals. Because the input of the bell filter 3 is kept properly and signals ranging from slightly small to large ones can be processed at the same level, it is possible to stabilize the frequency characteristic of the bell filter 3.

The signal level of the ACC detector 42 is detected as the input of the bell filter 3. To cancel the fluctuation of input/output gains of the bell filter 3, however, it is only necessary to use the output side of the bell filter 3 as the input side of the ACC detector 42.

Automatic adjustment is described below by referring to FIGs. 5 and 6.

The central frequency of the bell filter 3 is just 4.286 MHz as described above and this signal is not present in incoming chroma signals. Therefore, an embodiment for generating the reference signal inside is described below by referring to FIG. 5. A reference signal generating circuit 51 generates a 4.286 MHz signal with a high accuracy by using crystal or the like. A switch SW_5 is newly set between the 4.3 MHz BPF 1 and the switch SW_1. The reference signal f_1 of the reference signa generating circuit 51 is inputted to an input terminal A. A four-part-divider 52 generates the signal f_2 obtained by dividing the reference signal f_1 into four parts. The output terminal of the four-part-divider 52 is connected to the input terminal A of a switch SW_6 set between the switch SW_3 and the 1.1 MHz BPF. The switches SW_5 and SW_6 are driven by a key pulse KP. Because there is no chroma signal in the vertical retrace line period, the key pulse KP uses a pulse in any period close to the vertical synchronization period. The switches SW_5 and SW_6 are set to the side of the signals f_1 and f_2 to introduce the reference signals f_1 and f_2 into the BPFs 1 and 6 respectively. Because the reference signals are thus connected to the BPFs 1 and 6 respectively, the signals f_1 and f_2 are supplied to the bell filter 3 and the antibell filter 8 which are respectively located after the BPFs 1 and 6. Therefore, the reference signals can be inputted to the bell filter 3 and antibell filter 8.

The automatic adjustment system for each filter is described below by referring to FIG. 6. A signal introduced into a bell filter 60 (corresponding to the bell filter 3 in FIG. 1) is also supplied to a phase comparator 61. A signal at a point where the phase of the central frequency shifts by 90° is fetched from the internal circuit of the bell filter 60 and supplied to the input terminal of the phase comparator 61. The phase comparator 61 is driven by the key pulse KP so that it operates only for the key pulse period. The result of phase comparison is smoothed by a capacitor C_1 and supplied to a voltage-current converter 62. According to the phase comparison result which is current-converted by the converter 62, the current gain is changed to 1 or 1/4 by a current changing circuit 63. Change of current gains is driven by a recording/reproducing mode signal. The bell filter 60 is driven by the current signal which changed gains to apply feedback.

When the central frequency of the bell filter 60 is deviated from 4.286 MHz, a signal appearing at a 90-phase-signal output terminal deviates from 90° for the reference signal. The phase comparator 61 detects the deviation and charges the capacitor C_1 (or make the capacitor C_1 discharge). Then, the current value for controlling the filter changes and controls the signal appearing at the 90°-phase-signal output terminal so that the signal approaches 90°. When the control finally converges, the 90°-phase terminal signal of the bell filter 60 accurately comes to 90° for the reference signal and the central frequency can accurately be adjusted to the reference signal or 4.286 MHz. The same is also applied to the antibell filter 8. That is, a central frequency accurately equal to the reference signal can be obtained by fetching a signal from a point where the phase shifts by 90° and comparing phases.

In FIG. 5, because signals supplied to the bell filter 3 and antibell filter 8 are different in frequency from each other, a second reference signal which is 1/4 the reference signal is generated by the four-part-divider 52 and supplied to the filters 3 and 8. The reference signal generating circuit 51 and the four-part-divider 52 are generally constituted with a pulse circuit and the reference signal frequently becomes a rectangular wave. In this case, when directly extrapolating the reference signal for the bell filter 3 and antibell filter 8, an error occurs due to the distortion component of the reference signal and the adjustment accuracy is degraded. To avoid this, a switch is set to the inputs of the BPFs 1 and 6 respectively so that the reference signals f_1 and f_2 pass through the BPFs 1 and 6. Thus, it is possible to suppress the distortion of the reference signal and input a reference signal with less distortion to the bell and antibell filters by using the current BPFs in common without increasing the number of BPFs.

This embodiment makes it possible to input the reference signal operating at its frequency and having less distortion to bell and antibell filters because a switch is set between the input terminal of the bell filter 3 and antibell filter 8 and the output terminal of BPFs 1 and 6 as described above.

Because this embodiment changes the reference signal to a bell or antibell operating at the frequency of the reference signal because a switch is set between the input terminal of the bell filter 3 and antibell filter 8 and the output terminal of BPFs 1 and 6 as described above, there is an advantage that it is unnecessary to add a BPF-output changing circuit only by inputting the reference signal to the BPFs. In FIG. 2, for example, the bell filter operates at 4.3 MHz for recording and supplies the output signal of the 4.3 MHz BPF 1 by the switch SW_2. For reproduction, the bell filter is operated by the 1.1 MHz BPF 6. In this case,

however, the switch SW_2 is set to the 1.1 MHz BPF 6 side and the reference signal passing through the BPF 6 is supplied to the bell filter 3. This is also applied to the antibell filter 8.

The embodiment described above is a method for inputting an automatic adjustment signal to each filter. However, there are two other methods which are described below without illustrating them. In the case of the insertion method in FIG. 5, two reference signals are used and at the same time, a signal with a desired frequency is inputted to bell and antibell filters. However, because step-down and multiplication of frequencies are performed for recording or reproduction, either reference signal is generated also in a signal path.

The first method is a method of using only the 4.286 MHz reference signal, in which a reference signal is supplied to the input of the 4.3 MHz BPF filter 1 during the key pulse period by the switch SW_5 in FIG. 5. In this case, the switch SW_6 and the four-part-divider 52 in FIG. 5 are not used and the switches SW_1 to SW_4 are all set to the recording side. Then, the output of the 4.3 MHz BPF 1 is introduced into the bell filer 3. The reference signal passing through the bell filter 3 passes through the four-part-divider 5, the distortion of the signal is removed by the 1.1 MHz BPF 6, and the signal reaches the antibell filter. Because the antibell filter 8 receives the reference signal (after divided into four parts) from the switch SW_4, it is only necessary to automatically adjust the signal but the reference signal f_2 in FIG. 5 is unnecessary.

The second method is a method of using only the 1.0715 MHz reference signal unlike the first method. In this case, the reference signal generating circuit 51 generates a signal of approx. 1.1 MHz, the dividing stage can be omitted. The reference signal is supplied to the input of the 1.1 MHz BPF 6 by the switch SW_6 in FIG. 5 during the key pulse period. In this case, the switches SW_1 to SW_4 are all set to the reproduction side without using the switch SW_5. Then, the output of the 1.1 MHz BPF 6 is introduced into the bell filter 3, while the reference signal passing through the bell filter 3 passes through the four-time-multiplier 9 to suppress the distortion by the 4.3 MHz BPF 1 and reaches the antibell filter 8. Because the bell filter 3 can automatically be adjusted by the signal, the reference signal f_1 in FIG. 5 is unnecessary.

The above two methods omit the dividing stage for reference signal generation.

In the above description, an oscillator using crystal or the like is used as a reference signal generating source. In the case of multichroma processing, crystal for a color sub-carrier wave is used for PAL/NTSC. Therefore, the case of using this is described below.

In view of frequency, the crystal of PAL has the frequency of 4.43361875 MHz which is close to the central frequency of bell. Therefore, the case of using this is described below. A frequency changing circuit uses a DAC (digital-to-analog converter) instead of using a simple shunt-voltage shunt-current circuit for control information. To adjust the central frequency of a bell filter with the reference signal of PAL frequency, DAC is set to a certain value, the reference current of DAC is controlled by the output of a phase comparator, and DAC output current is supplied to the bell filter.

Under the above state, the central frequency of the bell filter comes to the PAL frequency. Therefore, when adjustment is completed and a chroma signal is made to pass, DAC data is changed and the central frequency of the bell is shifted. Because an example of this system is disclosed in Japanese Patent Application No. Hei 4-225640 (1992) applied by the applicant of the present invention, its detailed description is omitted. It is possible to perform the frequency shift of 4:1 with data and use the frequency change of 4:1 and the shift by DAC together.

FIG. 7 is a system diagram for explaining another embodiment of the present invention. This embodiment makes it possible to shift BPF frequencies similarly to the case of bell and antibell filters.

In FIG. 7, an SECAM color television signal supplied from the REC chroma input terminal IN_1 is supplied to a 4.3 MHz/1.1 MHz BPF 71 which uses 4.3 MHz for recording through a switch SW_7 in case of recording. The output of the BPF 71 is supplied to a 4.3 MHz/1.1 MHz bell filter 72, amplified by a limiter circuit 73, and divided into four parts by a four-part-divider 74, and thereafter supplied to a 1.1 MHz/4.3 MHz antibell filter 76 which uses 1.1 MHz for recording through a switch SW_8. The output of the BPF 75 is filtered through the 1.1 MHz/4.3 MHz antibell filter 76 and thereafter outputted from the chroma output terminal OUT.

In case of reproduction , an SECAM color television signal supplied from the PB chroma input terminal IN_2 is supplied to a 1.1 MHz BPF 71 and inputs chrome component to bell filter 72 through switch SW_7. The signal amplified by a limiter circuit 73, and divided into four parts by a four-part-divider 74 is supplied to a 4.3 MHz/1.1 MHz bell filter 75, through switch SW_8 in case of reproduction and thereafter supplied to 4.3 MHz antibell filter 76 and outputted through the 4.3 MHz antibell filter 76 from the chroma output terminal OUT.

The BPFs 71 and 75 and the bell filter 72 and antibell filter 76 connect with frequency changing circuits 78 and 79 to perform frequency shift and automatic adjustment with a control signal supplied to the control terminal P/R for recording/reproduction.

Thus, because signals are processed completely in one direction, it is possible to decrease the crosstalk frequency between recording and reproducing signals or between frequency bands. Moreover, it is possible to decrease the number of pins by disusing the switch SW_7 and using one pin for REC/PB chroma

input terminals IN_1 and IN_2.

As described above, the SECAM chroma processing circuit of the present invention makes it possible not only to incorporate filters into an IC but also to omit the adjustment of the filters.

The following is the description of still another embodiment.

This embodiment makes it possible to detect a phase by noticing the transfer function of an antibell filter and giving a characteristic for rotating a phase by 90° to a circuit constituting the antibell filter.

First, as shown in FIG. 8, an antibell filter is constituted by subtracting a certain transfer function H(s) from an input signal. In FIG. 8, symbol 810 represents an input terminal, 811 represents an output terminal, 812 represents a filter of a certain transfer function H(s), and 813 represents a subtracter.

When the transfer function of an antibell filter is assumed as AB(s) and a certain transfer function is assumed as assumed as AB(s) and a certain transfer function is assumed as H(s), H(s) can be shown as the following expression (10).

$$H(s) = 1 - AB(s) = \frac{(\frac{1}{Q_n} - \frac{1}{Q_p})\omega_0 S}{S^2 + \frac{1}{Q_n}.\omega_0 S + \omega_0^2} \quad (10)$$

H(s) is the transfer function of BPF. In this case, the BPF is transformed into the expression (11) by assuming input as X and output as Y.

$$X(\frac{1}{Q_n} - \frac{1}{Q_p})\ \omega_0 S = Y(S^2 + \frac{1}{Q_n}.\omega_0 S + \omega_0^2) \quad (11)$$

It is found that components are the primary integration term of input, the secondary integration term of output, and the primary integration term of output. This is shown in FIG. 9. In FIG. 9, symbol 920 represents an input terminal, 921 represents an output terminal, 922 to 924 represent Gm amplifiers, 925 to 927 represent capacitors, and 928 represents an adder.

In this case, it is noticed that the primary integration term of BPF is also obtained only by constituting the transfer function of BPF. That is, it is possible to obtain the transfer function of the secondary LPF shown in the following expression (12) at the point A.

$$\frac{(\frac{1}{Q_n} - \frac{1}{Q_p})\omega_0\ S}{S^2 + \frac{1}{Q_n}.\omega_0 S + \omega_0^2} \cdot \frac{\omega_0}{S} = \frac{(\frac{1}{Q_n} - \frac{1}{Q_p})\ \omega_0^2}{S^2 + \frac{1}{Q_n}.\omega_0 S + \omega_0^2} \quad (12)$$

embodiment of the present invention which makes it possible to automatically adjust the frequency of an antibell filter 1030 with a constitution of [1-(transfer function of BPF)]. In FIG. 10, symbol 1031 represents an input terminal to which an input signal is inputted. The input terminal 1031 is connected to the input of a Gm amplifier 1032, one input of a subtracter 1033, and one input of a phase detector 1034. The output of the Gm amplifier 1032 is connected to the other input of the subtracter 1033 through a buffer 1035 and also connected to the inputs of Gm amplifiers 1036 and 1037. The output of the Gm amplifier 1036 is connected to the input of the buffer 1035. The output of the Gm amplifier 1037 is grounded through a capacitor 1038 and simultaneously connected to the input of a buffer 1039. The output of the buffer 1039 is connected to the input of a Gm amplifier 40 and also connected to the other input of the phase detector 1034. The output of a Gm amplifier 1040 is grounded through a capacitor 1041 and simultaneously connected to the input of the buffer 1035. The output of the phase detector 1034 is connected to the input of a Gm control circuit 1042. A control output 1043 of the Gm control circuit 1042 is connected to the control terminal of the Gm amplifier 1037, a control output 1044 of it is connected to the control terminal of the Gm amplifier 1040, a control output 1045 of it is connected to the control terminal of the Gm amplifier 1032, and a control output 1046 of it is connected to the control terminal of the Gm amplifier 1036. The output of the subtracter 1033 is connected to an output terminal 1047.

Operations of the system in FIG. 10 are described below. First, a case is considered in which the central frequency f_0 of the antibell filter to be controlled equals 4.286 MHz. In this case, the phase of the output signal of the secondary LPF has the characteristic shown by B in FIG. 11. The phase of the output of the secondary LPF having the input signal of 4.286 MHz rotates by 90° to the input signal.

The operation of the phase detector 1034 is described below by referring to FIG. 12 which shows a concrete example of the phase detector 1034. Input terminals are shown by a, a', b, and b' and an output terminal is shown by c. When assuming a signal inputted to the input terminal 1031 in FIG. 10 as a differential signal of 4.286 MHz (same frequency as f_0 of the antibell filter), the voltage waveforms at the input and output solid of the phase detector 1034 are shown by the continuous lines in FIG. 13. Because the phases of the signals inputted to the input terminals b and b' are rotated by 90° from those of the signals inputted to the input terminals a and a', the duty of the output waveform c comes to 50% and the average value of the waveform comes to 0.

When the Gm control circuit 1042 shown in FIG. 10 controls the Gm amplifiers 1032, 1036, 1037, and 1040 respectively in accordance with the average value of the phase detector 1034, Gm of each Gm amplifier does not change because the average value of output voltages is 0. That is, the state is realized in which f_0 equals 4.286 MHz.

Then, a case is considered in which f_0 of the antibell filter equals 5 MHz. When a signal of 4.286 MHz is inputted to the antibell filter, the phase of the output signal of the secondary LPF comes to "-90°+{-90°-(-68°)}=-112°". Therefore, the phase rotates by 112° to the input signal.

In this case, the voltage waveform in the phase detector 1034 is shown by a broken line in FIG. 13. The duty of the output waveform c is out of 50% and the average value of the waveform becomes negative. That is, this voltage makes it possible to control the Gm amplifiers 1032, 1036, 1037, and 1040 and decrease f_0 of the antibell filter.

FIG. 14 is a circuit block diagram for explaining another embodiment of the present invention which makes it possible to automatically adjust the frequency of an antibell filter 30 with the constitution of [1-(transfer function of BPF)].

The embodiment in FIG. 14 is different from the embodiment described in FIG. 10 in that the point from which the signal inputted to the phase detector 1034 is fetched is changed. In FIG. 10, the input signal of the antibell filter and the output signal of the secondary LPF are inputted to the phase detector 1034. In FIG. 14, however, the secondary-LPF output signal and the antibell-filter output signal are inputted to the phase detector 1034. FIG. 11 shows these phase characteristics. In FIG. 11, symbol A represents the phase characteristic at the output terminal of the antibell filter and B represents the phase characteristic at the output terminal of the secondary LPF. Therefore, symbol C represents the phase difference between A and B. From the characteristic C, it is found that a characteristic steeply rising at the point f_0 is obtained.

When assuming the phase of a signal at the output terminal of the antibell filter to be standard, the input phase difference between a and a' on one hand and b and b' on the other of the phase detector 1034 comes to "-90°+{-90°-(-13°)}=-167°". The then input and output voltage waveforms of the phase detector 1034 are shown by broken lines in FIG. 15. Because the average value of the voltage waveform c gets larger than that in the case of FIG 10, the control capacities of the Gm amplifiers 1032, 1036, 1037, and 1040 are improved. That is, this embodiment makes it possible to realize an accurate automatic frequency adjusting system compared with the system in FIG. 10.

As described above, the automatic frequency adjusting circuit of the present invention makes it possible to automatically and very accurately adjust the central frequencies of bell and antibell filters built in an IC. Moreover, it is possible to prevent element characteristics from deteriorating with age.

Claims

1. An SECAM chroma processing circuit having a first mode for extracting a chroma signal from a first signal, making the signal pass through a bell filter (3), and thereafter extracting only a desired component by diving the signal into four parts to make the signal pass through an antibell filter (8) and a second mode for extracting a chroma signal from a second signal, making the signal pass through the bell filter (3), and thereafter extracting only a desired component by multiplying the signal up to four times to make the signal pass through the antibell filter (8); wherein

   frequency characteristics of the bell filter (3) and the antibell filter (8) can be shifted, the frequency characteristic of the bell filter (3) is shifted to the frequency of the first signal and the frequency characteristic of the antibell filter (8) is shifted to the frequency of the second signal in the first mode, and the frequency characteristic of the bell filter (3) is shifted to the frequency of the second frequency and the frequency characteristic of the antibell filter (8) is shifted to the frequency of the first signal in the second mode.

2. The SECAM chroma processing circuit of claim 1, wherein

   ACC circuits (41 and 42) are set before at least one of the bell filter (3) and the antibell filter (8).

3. The SECAM chroma processing circuit of claim 1, wherein

   changeover switches (SW_2 and SW_4) are set before at least either of the bell filter (3) and the antibell filter (8) and the chroma signal is inputted to the bell filter (3) or the antibell filter (8) which operates at a desired frequency.

4. The SECAM chroma processing circuit of claim 1, wherein

   the bell filter (3) or the antibell filter (8) is constituted with an active filter capable of controlling frequency characteristics with current or voltage and frequencies are changed by shunt current or shunt voltage of control information.

5. The SECAM chroma processing circuit of claim 1, wherein

   a chroma signal and a desired component are extracted on a frequency axis by filters (71 and 75) capable of shifting characteristics and means (78 and 79) for changing frequency characteristics of the filters (71 and 75) by interlocking with the frequency change of the bell filter (72) and the antibell filter (76) are included.

6. The SECAM chroma processing circuit of claim 5, wherein

   a chroma signal input terminal (SW_7) is shared by a first mode and a second mode.

7. The SECAM chroma processing circuit of claim 1, wherein

a reference signal generating circuit (51) for obtaining reference signals (f_1 and f_2) of a plurality of predetermined frequencies is included, and means (SW_5 and SW_8) for simultaneously introducing the reference signals (f_1 and f_2) into the bell filter (3) and the antibell filter (8) respectively within the vertical retrace line period, means for comparing the phases of the reference signals (f_1 and f_2) in the bell filter (3) and the antibell filter (8) each other, means (61) for detecting whether the difference of the phases compared by the comparing means is kept at a predetermined value, feedback means for controlling the central frequencies of the bell filter (3) and the antibell filter (8) with a signal detected by the means (61) and finally converging the difference between the phases to a predetermined value, and means for holding the converged phase difference for a period other than the vertical retrace line period are included.

8. The SECAM chroma processing circuit of claim 1, wherein

a reference signal generating circuit for obtaining the reference signal of a single predetermined frequency is included, and changing means for inputting the reference signal to the bell filter (3) within the vertical retrace line period, means for fixing all changing means of a chroma signal path to a first mode at least during the change to the reference signal, means for comparing the phases of the reference signals in the bell filter (3) and the antibell filter (8) each other, means for detecting whether the difference of the phases compared by the comparing means is kept at a predetermined value, feedback means for controlling the central frequencies of the bell and antibell filters with a signal detected by the detecting means and finally converging the phase difference to a predetermined value, and means for holding the converged phase difference for a period other than the vertical retrace line period are included.

9. The SECAM chroma processing circuit of claim 1, wherein

a reference signal generating circuit for obtaining the reference signal of a single predetermined frequency, and changing means for inputting the reference signal to the bell filter (8) during the vertical retrace line period, means for fixing all changing means of a chroma signal path to a second mode at least during the change to the reference signal, means for comparing the phases of reference signals in the bell filter (3) and the antibell filter (8) each other, means for detecting whether the difference of the compared phases is kept at a predetermined value, feedback means for controlling the central frequencies of bell and antibell filters with a signal detected by the detecting means and finally converging the phase difference to a predetermined value, and means for holding the converged phase difference for a period other than the vertical retrace line period.

10. The SECAM chroma processing circuit of claims 7 to 9, wherein

a reference signal is introduced into a bell filter (3) or an antibell filter (8) by changing input terminals of means for extracting a chroma signal present before the bell filter (3) of the antibell filter (8).

11. The SECAM chroma processing circuit of claims 7 to 9, wherein

the frequency changing means is arranged between feedback means and a bell filter and between the feedback means and an antibell filter (8) respectively.

12. An automatic frequency adjusting circuit for automatically adjusting the frequency of a bell or antibell filter (1030) having the secondary LPF characteristic, comprising:

a phase detecting circuit (1034) for detecting the phase of the input inputted to and the output outputted from the bell or antibell filter (1030); and

a control circuit (1042) for applying feedback to the bell or antibell filter with the output signal of the phase detecting circuit.

13. An automatic frequency adjusting circuit for automatically adjusting the frequency of a bell or antibell filter (1030) having the secondary LPF characteristic, comprising:

a phase detecting circuit (1034) for detecting the phases of the secondary-LPF output and the bellor antibellfilter output; and

a control circuit (1042) for applying feedback to the bell or antibell filter with the output signal of the phase detecting circuit.

14. The automatic frequency adjusting circuit of claim 12 or 13, wherein

the transfer function of an antibell filter is shown as [transfer function of antibell filter]=1-[transfer function of BPF].

FIG. 1

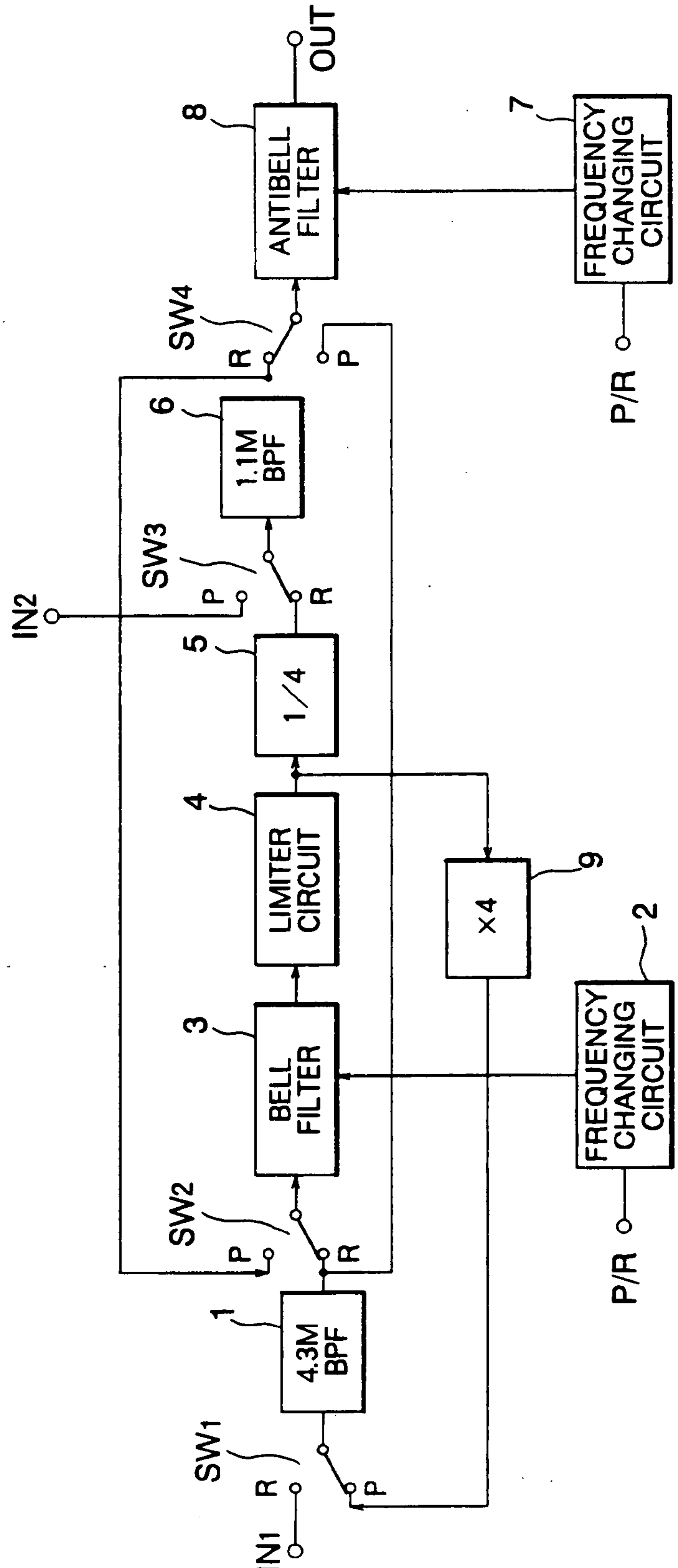

IN1
R
P
SW1
4.3M
BPF
1
SW2
P
R
BELL
FILTER
3
LIMITER
CIRCUIT
4
1/4
5
IN2
SW3
P
R
1.1M
BPF
6
SW4
R
P
ANTIBELL
FILTER
8
OUT
×4
9
FREQUENCY
CHANGING
CIRCUIT
2
P/R
FREQUENCY
CHANGING
CIRCUIT
7
P/R

FIG. 2

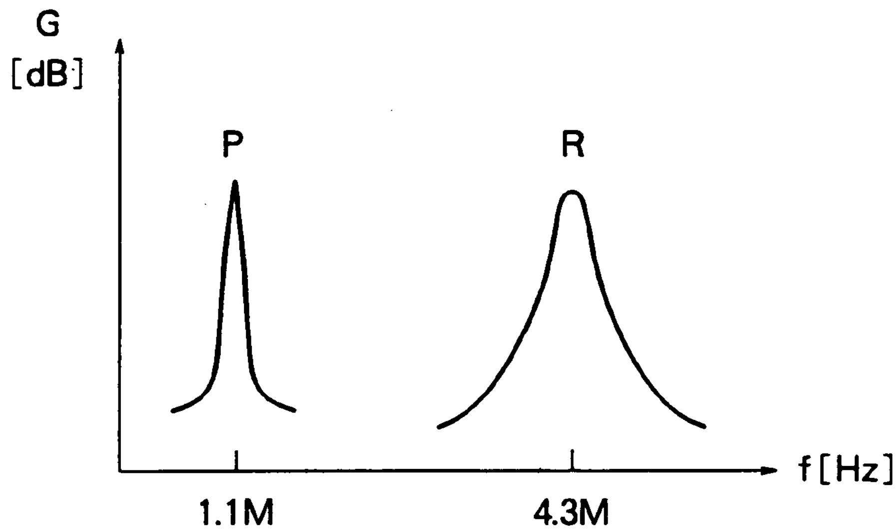


FIG. 3

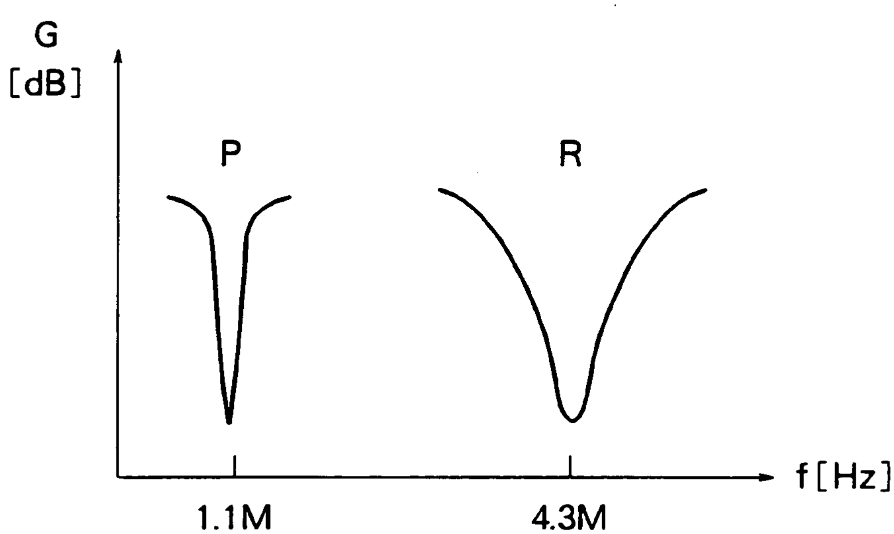


FIG. 4

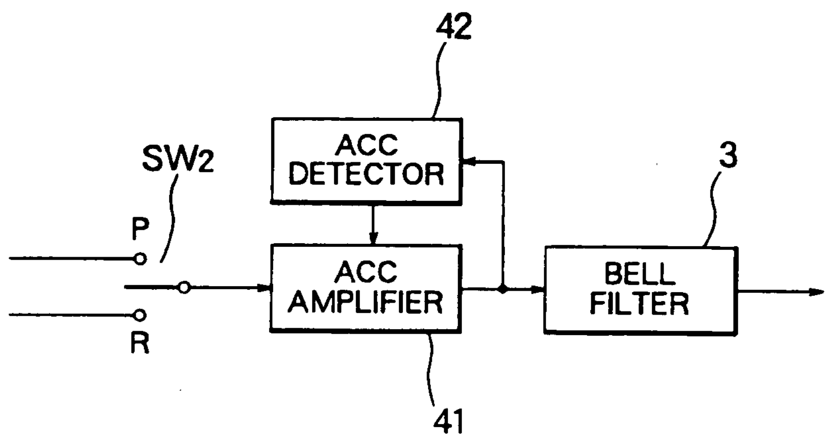


FIG. 5

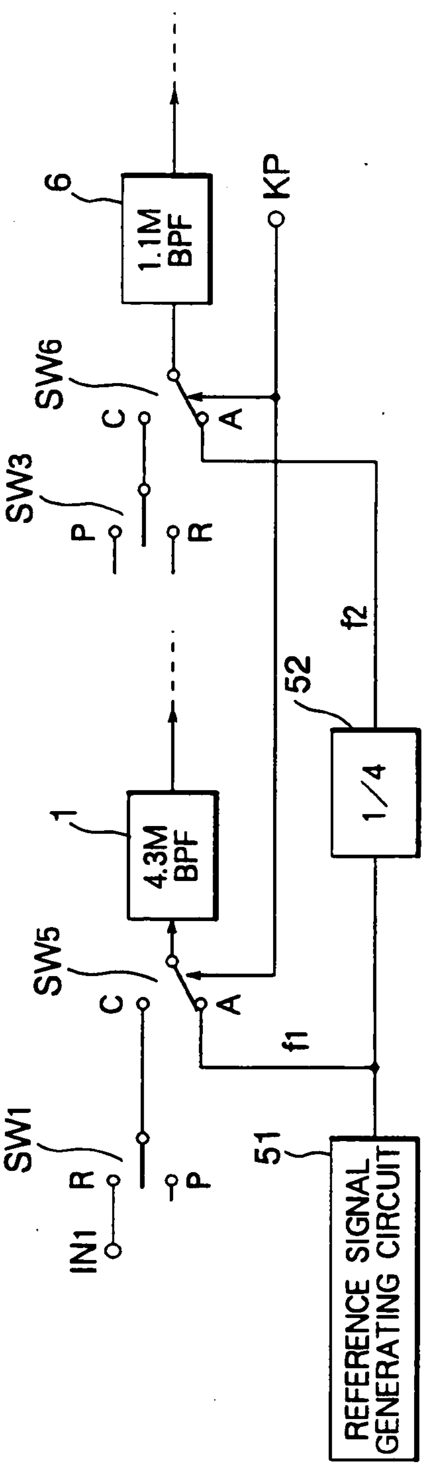
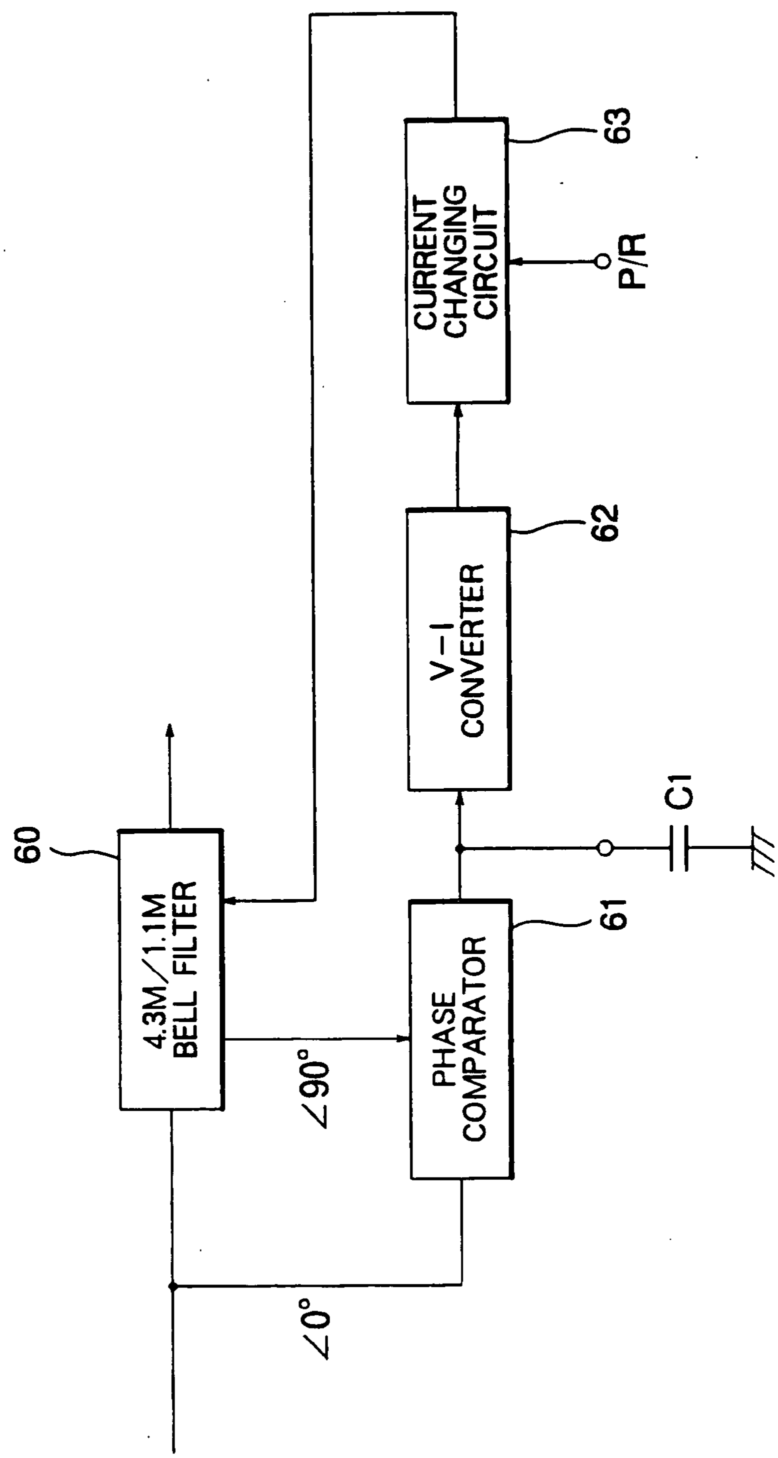

IN1
SW1
R
P
C
A
SW5
1
4.3M BPF
f1
51
REFERENCE SIGNAL GENERATING CIRCUIT
52
1/4
f2
SW3
P
R
C
A
SW6
6
1.1M BPF
KP

FIG. 6



4.3M/1.1M BELL FILTER
60
PHASE COMPARATOR
61
V−I CONVERTER
62
CURRENT CHANGING CIRCUIT
63
P/R
C1
∠90°
∠0°

FIG. 7

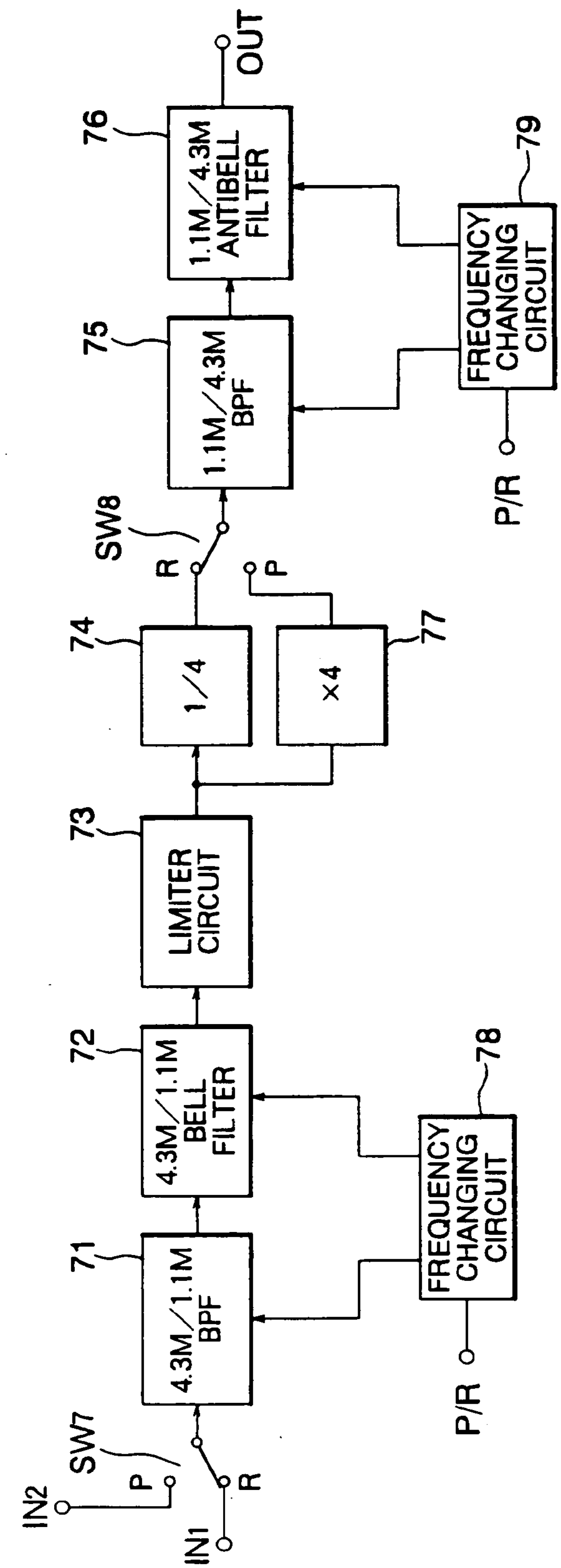

IN2
IN1
P
R
SW7
71
4.3M/1.1M BPF
72
4.3M/1.1M BELL FILTER
73
LIMITER CIRCUIT
74
1/4
77
×4
78
FREQUENCY CHANGING CIRCUIT
P/R
R
P
SW8
75
1.1M/4.3M BPF
76
1.1M/4.3M ANTIBELL FILTER
OUT
79
FREQUENCY CHANGING CIRCUIT
P/R

FIG. 8

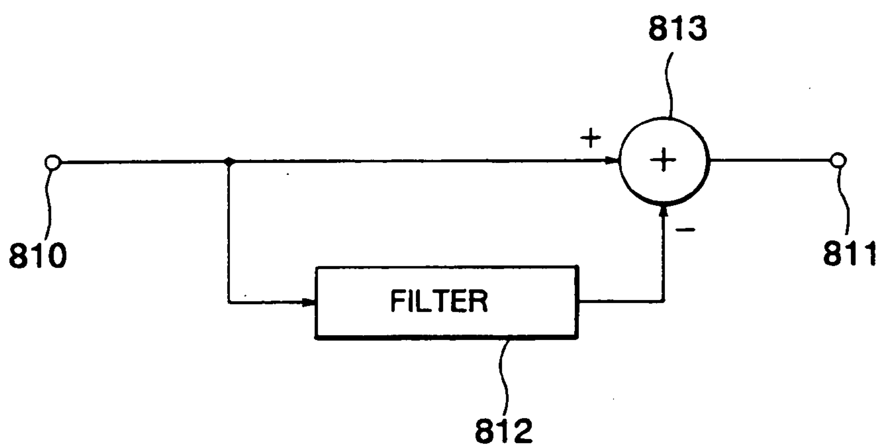


FIG. 9

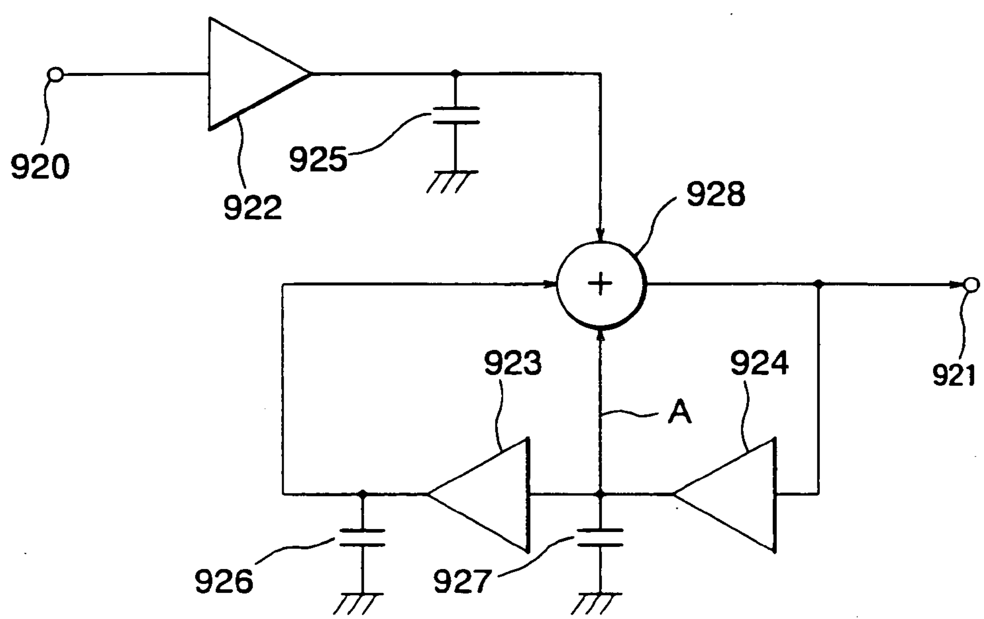


FIG. 10

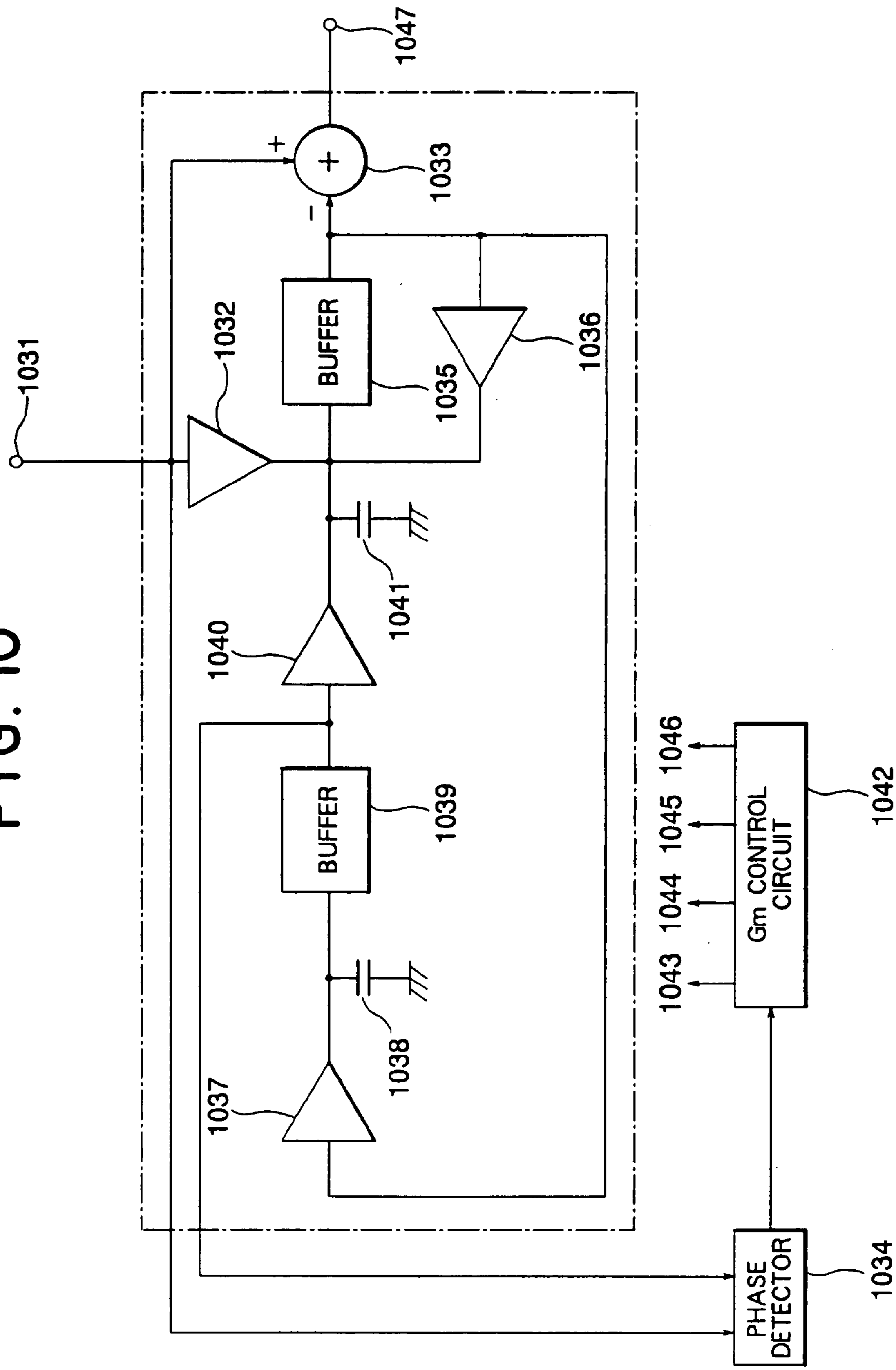

1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
BUFFER
BUFFER
Gm CONTROL CIRCUIT
PHASE DETECTOR
+
+
−

FIG. 11

ANTIBELL PHASE CHARACTERISTIC DIAGRAM

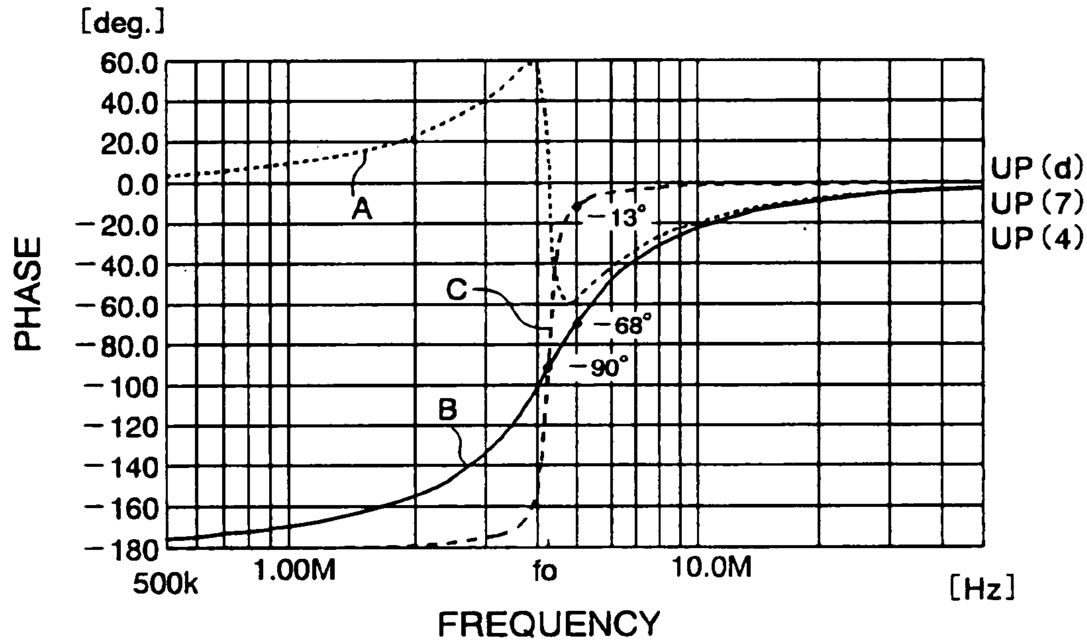


FIG. 12

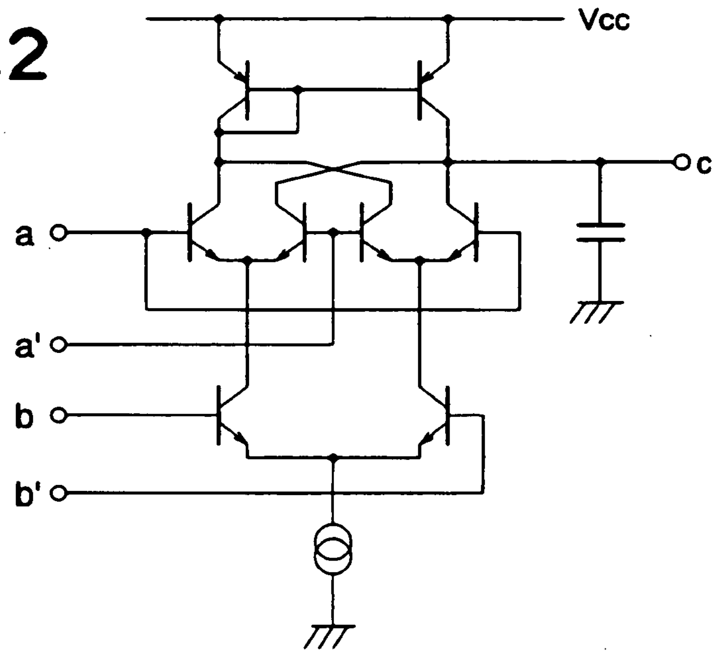


FIG. 13

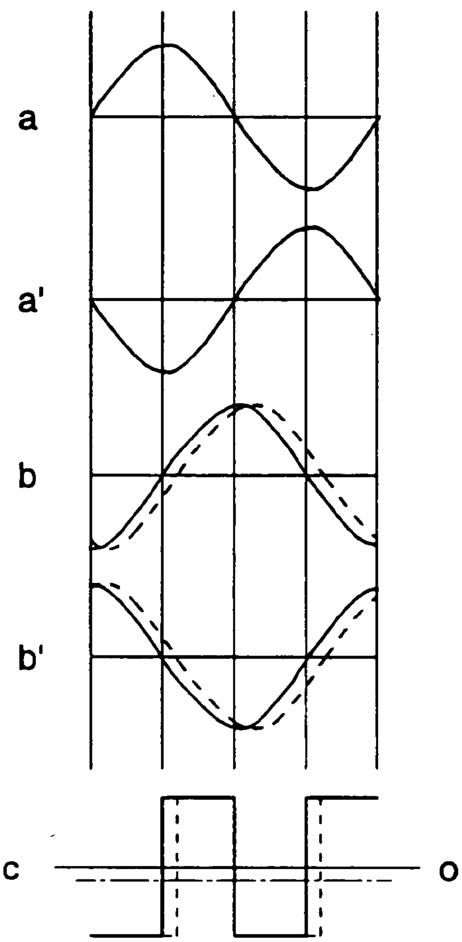


FIG. 14

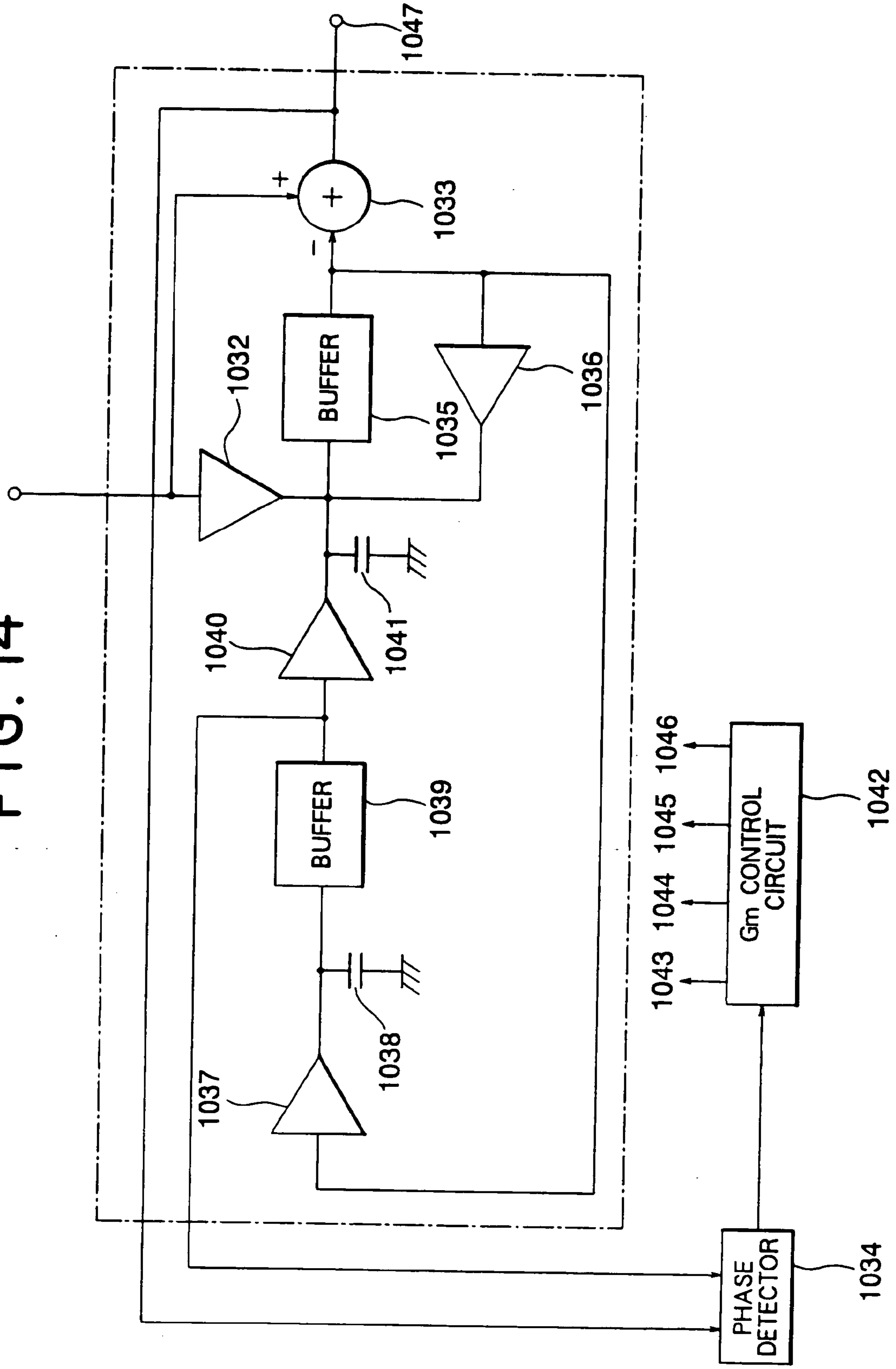

1047
1033
BUFFER
1035
1036
1032
1040
1041
BUFFER
1039
1037
1038
1046
1045
1044
1043
Gm CONTROL CIRCUIT
1042
PHASE DETECTOR
1034

FIG. 15

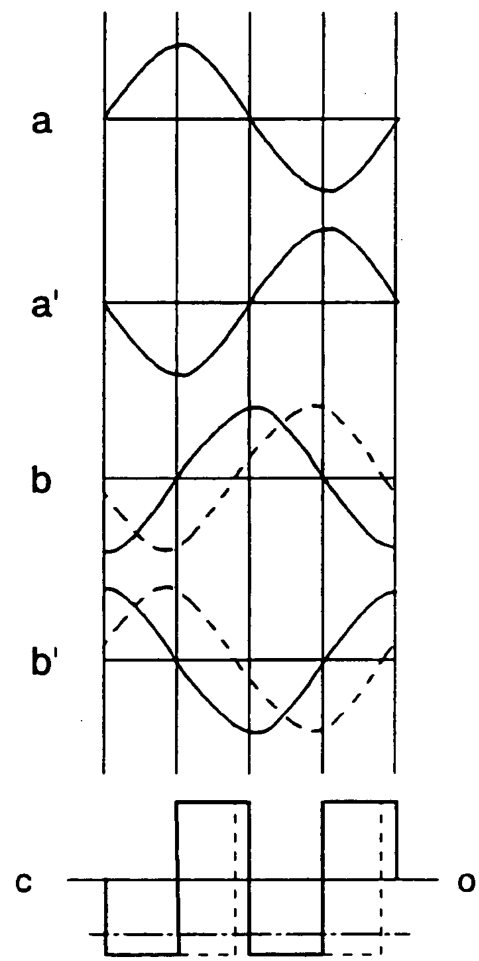


FIG. 16

PRIOR ART

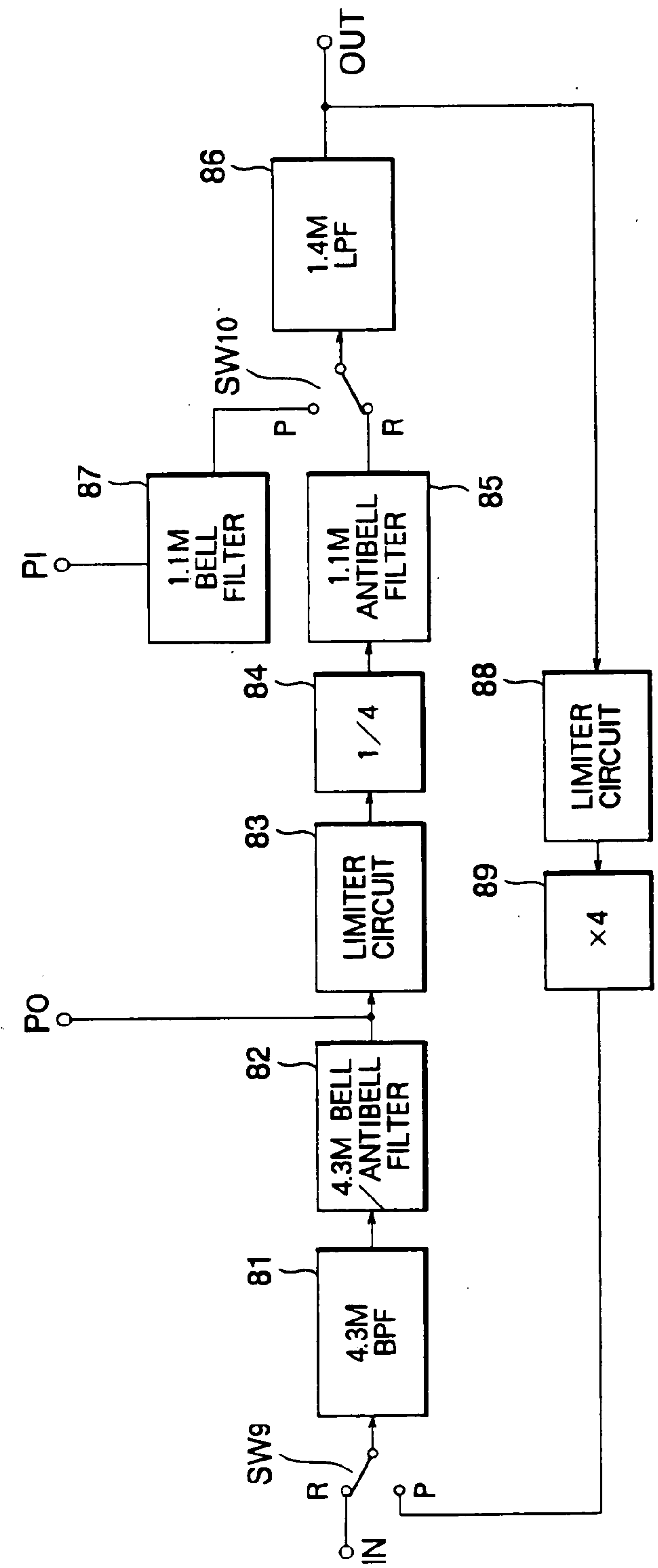


FIG. 17

PRIOR ART

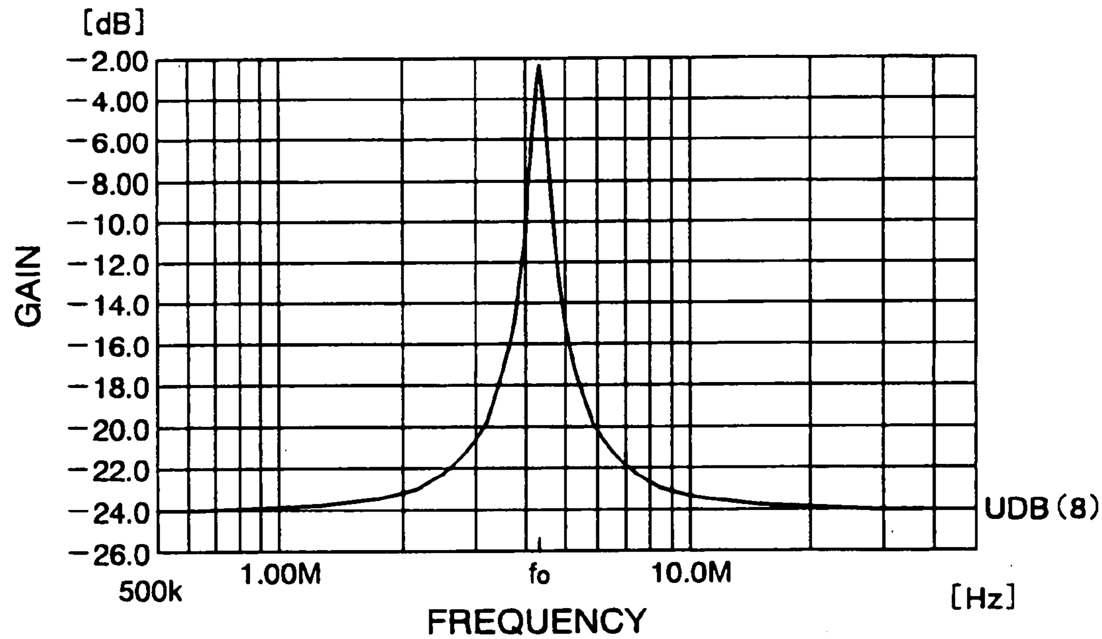


FIG. 18

PRIOR ART

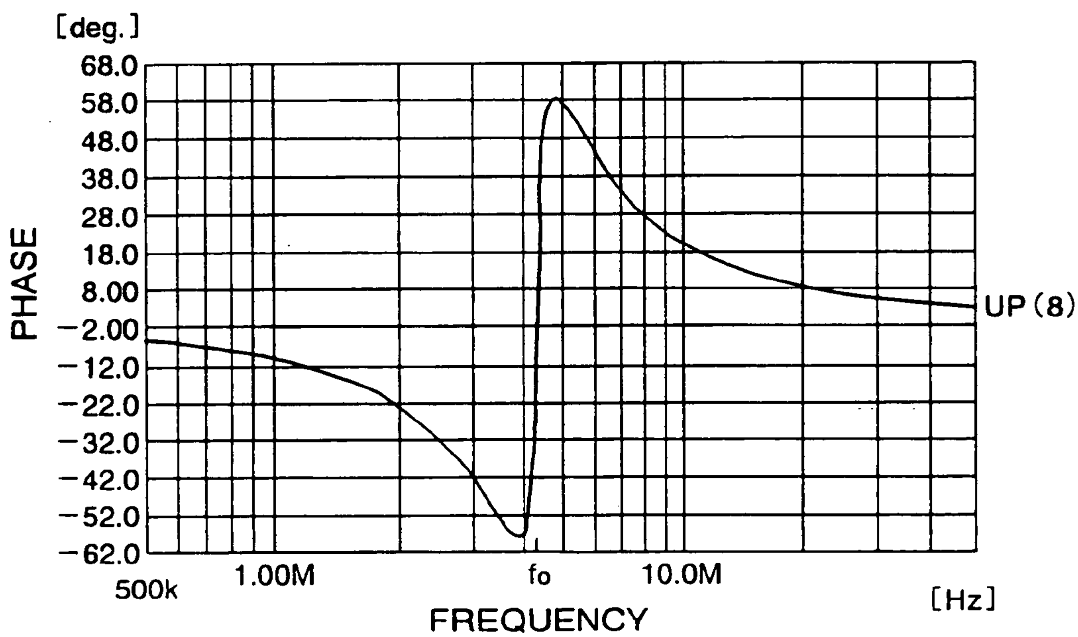


FIG. 19

PRIOR ART

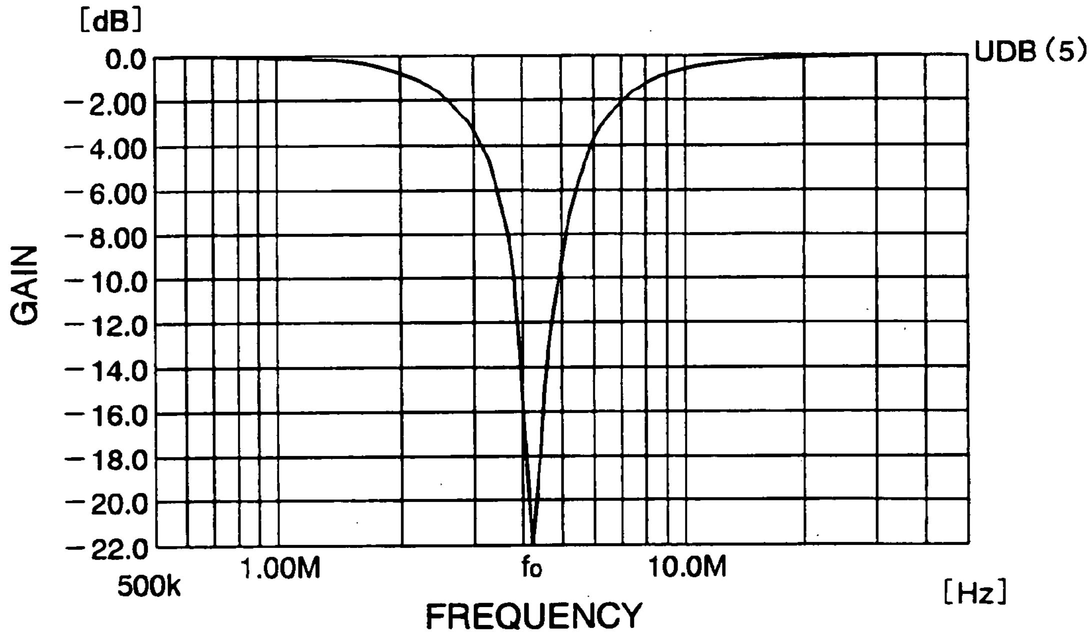


FIG. 20

PRIOR ART

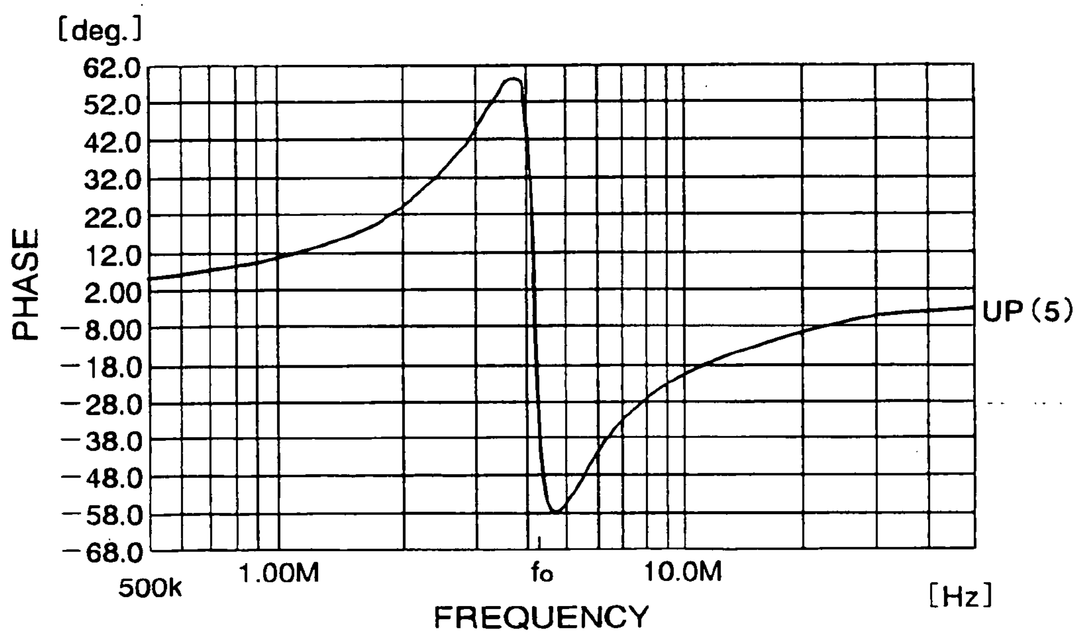


FIG. 21

PRIOR ART

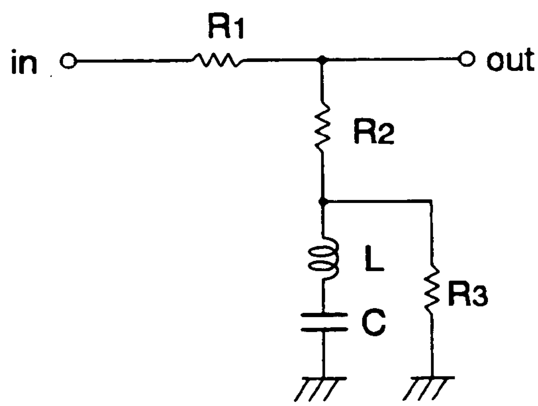


FIG. 22

PRIOR ART

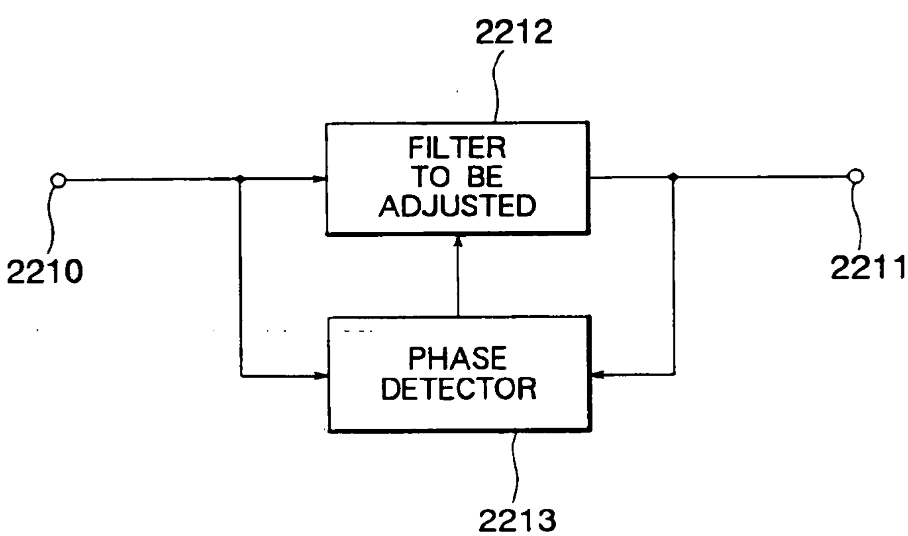


FIG. 23

PRIOR ART